Umbilical Manufacturer’s Perspective on the Challenges of Deep Water Operations

Presented by: James Young, JDR Engineering Director

PROVIDING THE VITAL CONNECTION
1. Introduction

2. JDR Cables and Umbilicals


4. Deepwater Umbilical Options for Future Fields

5. Summary
JDR is a world-class provider of technology connecting the global offshore energy industry. Our products and services enable vital control and power delivery to offshore oil, gas and renewable energy systems. We have a proven track record of delivering client expectations and are totally committed to lifecycle customer service. We achieve this through our specialist engineering teams, experienced project management, integrated safety systems and a global service network that ensures 24/7 global service support.
**OUR MARKETS**

**Oil & Gas**
JDR leads the field in custom engineered products for the offshore oil and gas industry. We have developed technologies that maximise the efficient delivery of power, control and communications through umbilicals and power cables. Using our state-of-the-art engineering and manufacturing capabilities, we develop and deliver custom built systems for subsea installations at ever increasing water depths.

**Renewables**
We have embraced the growing international market for alternative and sustainable energy delivery. Our UK east coast locations makes us ideally located to provide, engineering, manufacturing and installation services for the evolving renewables market, which is particularly strong in Europe.

**Global Services**
Global aftermarket, installation and maintenance services are provided by our Global Services division. Global Services has a network of experienced and certified technicians and service support facilities, available 24/7 to manage customer projects, for JDR and non-JDR products, on or offshore. The team has created periodic maintenance and inspection routines that include product lifecycle preventative maintenance and assurance programmes.
Over 500 employees in 10 different countries. We stand ready, 24/7, to innovate and assist your subsea projects.
A self-supporting (vessel-deployed) IWOCS umbilical being used to perform an intervention on a subsea tree (IWOCS Reeler Range+)

A dynamic subsea production umbilical (SPU), connecting an FPSO (1) to a subsea umbilical termination assembly (SUTA), delivering critical power, chemical/hydraulic injection, control and monitoring links from FPSO to subsea trees/manifolds

A dynamic subsea power cable (SPC) delivering electrical power from platform-to-platform.

A static shore-to-platform subsea power cable (SPC).

An MV renewable energy cable (REC), specifically an inter-turbine array cable. Array cables from 33kV to 72kV including connections & accessories

Steel Tube Flying Leads (STU)

Steel Tube static umbilicals (STU)
• JDR designs, creates and delivers world-class subsea products and services for many of the world’s major energy companies and subsea service providers
  • Subsea Production Umbilicals
  • Subsea Power Cables
  • Intervention Workover Control Systems (IWOCS)
  • Renewable Energy Inter-Array Cables
  • Subsea Engineering Equipment and Global Services
• Global Services Division: JDR’s installation and maintenance support service
  • Supporting customers from project installation to pre-commissioning with full product lifecycle support
  • Delivered by a network of experienced technicians and 24/7 service support team
  • An integrated approach from test to assurance programmes
SUBSEA PRODUCTS – CABLES & UMBILICALS

MEDIUM (33kV) TO HIGH-VOLTAGE (72kV) SUBSEA POWER CABLES

THERMOPLASTIC, STEEL TUBE AND HYBRID PRODUCTION UMBILICALS FOR DEEPWATER APPLICATIONS
DEEPWATER UMBILICAL CHALLENGES: DYNAMIC LOADING

- Fatigue due to dynamic vessel motion
  - Impact on reinforcement
  - Impact on tubes and cables
  - Fatigue analysis performed

- Interference/Clashing assessment
  - Distributed buoyancy/ballast design
  - Internal umbilical ballasting
  - Optimising diameter-to-weight ratio

- Managing the umbilical touch-down
  - Hold-back clamps
  - Umbilical abrasion protection
  - Additional ballast
DEEPWATER UMBILICAL CHALLENGES: INCREASED SERVICES TO SEABED

- Increasing requirements with distance for:
  - Comms – attenuation and cross-talk
  - Electrical power losses
  - Hydraulic pressure losses

- External pressures
  - Design for collapse resistance
  - Connection interfaces and sealing

Source - SUT InDepth Dec-13
DEEPWATER UMBILICAL CHALLENGES: INSTALLATION & OPERATION

• Challenge on how to minimise umbilical weight
  • Increasing use of lighter weight materials to reduce installation and operating loads
  • Increased use of polymers or carbon fibre
  • Aluminium vs copper conductors – Al has been used as a conductor in the land cable industry for decades
  • Hybrid steel/ thermoplastic options for components and reinforcement

• Can recent advances in synthetic fibre materials be used to address the deepwater challenge?
  • Higher strength yarns
  • Improved factory processes and machine routings
  • Improved abrasion resistance

• Can functional component selection be optimised:
  • The right number of functions
  • Provide the best solution for the deepwater installation
  • Ensure the precisely required level of reliability is present in the design

Source - SUT InDepth Dec-13
DEEPWATER UMBILICALS: IWOC – CLAMPED

Wireline Deployed IWOC system
DEEPWATER UMBILICALS: SELF-SUPPORTING IWOCS

A key component of the system is JDR’s patented high strength termination assembly, the system employs a capstan grip effect over a series of torus rings removing over 75% of the tension from the retaining clamp.

<table>
<thead>
<tr>
<th>Description</th>
<th>BL</th>
<th>kN</th>
<th>lbs</th>
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</thead>
<tbody>
<tr>
<td>Umbilical Predicted BL</td>
<td>636</td>
<td>kN</td>
<td>143,000</td>
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<tr>
<td>Terminated Min. BL</td>
<td>323</td>
<td>kN</td>
<td>72,500</td>
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<tr>
<td>Terminated Max. SWL</td>
<td>100</td>
<td>kN</td>
<td>22,500</td>
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HIGH CYCLE VARIABLE LOAD FATIGUE TEST

• Test programme criteria derived from dynamic analysis:

<table>
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<tr>
<th>Case</th>
<th>Cycles (N)</th>
<th>Mean Tension (kips)</th>
<th>Stroke Length (ft)</th>
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<tbody>
<tr>
<td>#1</td>
<td>57,302</td>
<td>7.44 +/- 2.1</td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>12,536</td>
<td>7.44 +/- 3.96</td>
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<tr>
<td>#3</td>
<td>16,372</td>
<td>8.59 +/- 2.1</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>3,582</td>
<td>8.59 +/- 3.96</td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td>8,186</td>
<td>19.25 +/- 2.1</td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>1,791</td>
<td>19.25 +/- 3.96</td>
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</tr>
<tr>
<td>#7</td>
<td>232</td>
<td>28.2 +/- 10.73</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100,000</td>
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</table>

• 28.2 kips = 125 kN (12.5 Tonne)
• 19.25 kips = 85.6 kN (8.6 Tonne)
• No loss of cable or hose performance.
SELF SUPPORTING IWOC SYSTEMS

SELF-SUPPORTING IWOC UMBILICAL DESIGN – HIGH STRENGTH SYNTHETIC FIBRE TERMINATION

- Self locking of braid retainer
- Reaction points
- Tension in umbilical or cable
- Braid under full tension
- Capstan point
- Multiple torus additions

[Image of IWOC system components]
SELF SUPPORTING IWOCS QUALIFICATION SUMMARY

• Umbilical Tensile Break Test
  ▪ Achieved 441kN (99,100 lbs), before grips failed.
• Termination Tensile Break Test
  ▪ Achieved a breakload of 338 kN (76,000 lbs).
• Fatigue Due to Reeling
  ▪ Umbilical tested at 100kN (22,500 lbs) for 500 cycles at 1.9m bend diameter.
  ▪ No loss of component performance and the strength member was intact.
• Dissection following Umbilical Fatigue Test
  ▪ Some minor “dusted” fibre was observed upon fatigue sample dissection. JDR consider the strength member to be 95% intact following the test.
  ▪ The fatigued sample was tensile tested and withstood 255 kN (57,300 lbs) before the umbilical grips failed.
• Prototype Qualification achieved successfully Jan-2010
• Self-supporting IWOCS umbilicals have seen service > 3 years
During the umbilical qualification testing the test sample successfully completed 558 cycles at a test load of 10,150kg (99.5kN) with no signs of damage and all components passing the tests.

The above umbilical was manufactured in a continuous 3000m length.

The client used the umbilical earlier in 2013 to complete 16 Piles driven at a water depth of 1450 m with the umbilical operating for 9 days in self-supporting mode.
DEEPWATER HYBRID UMBILICALS - ROYAL NIGER, ABO 12 PHASE 3

- 1550m of Steel Tube Hybrid static umbilical
  - 3 x 3/4” Super Duplex Steel Tubes
  - 2 x 3/8” HP Thermoplastic Hose
  - 1 x 3/8” LP Thermoplastic Hose
  - 3 x 1/2” LP Thermoplastic Hose
  - 2 x 6mm2 LV Communications Pairs

- Terminations & UTA Integration at JDR

- Design optimised for function, service, installation and depth

- Delivered Jan 2015
DEEPWATER POWER CABLES – 72 KV AC WET-DESIGN

- Metallic barrier layers such as Lead, required for HV “Dry” insulation systems, can exhibit creasing or creep in dynamic umbilicals.
- JDR’s wet-design does not require a metallic barrier at 72 kV AC.
- The insulation system can be produced to achieve sufficient reliability in subsea applications without a heavy Lead, Copper or Aluminum hermetic metallic layer, previously used for HV.
- 72 kV wet-design cable is typically 25% lighter and costs less than a Lead option at the same voltage.
- DECC grant received by JDR for the high voltage cable development is also supported with a grant from the Offshore Wind Accelerator.
- Proof of concept cable completed in 2014
- Product in Qualification Testing in progress 2015

Achievable voltage rating with conductor size and insulation wall for Wet Design XLPe cores for an equivalent dielectric voltage stress.
SUBSEA POWER DISTRIBUTION – WAVEHUB UK

- **Wavehub Cable**
  - 25km
  - 6 X 300mm² @ 18/30(36)kV
  - Double Armour & Sheath
  - Delivered 2010

- **Wavehub Hub**
  - Passive Phase Core Splitter
  - Passive Optic Separation
  - Self-Stable

- **Wavehub Connectors**
  - In-board Weak-Link
  - 3 X 400A @ 6/10(12)kV
  - 12 X Single Mode Optic Fibres

- **Power distribution hubs needed for future deepwater applications**
- **Critical to develop sealing technology and deepwater connectors.**
IN SUMMARY

Advances in polymeric and composite umbilical design can enable:
- Use of Self-Supporting IWOCS Umbilicals to reduce overall operating costs for deepwater and ultra-deep applications.
- Extension of composite umbilical service-life and reliability in future could enable non-steel umbilicals for a range of nearer-term field operations.

Steel tube hybrid umbilicals and flying leads can:
- Reduce umbilical self-weight, thereby reducing the reinforcement required to support product installation.
- Increase umbilical flexibility during handling and subsea connection.
- Provide opportunities for overall system cost reduction.

72 kV AC wet-design cables have future deepwater benefits:
- Additional transmission and distribution power/ voltage options for subsea power infrastructure.
- Significant weight reductions over conventional HV designs with metallic radial moisture barriers.
- Potentially more vessel choice options when installing lighter weight deepwater power umbilicals.
- JDR’s 72 kV AC cable technology utilised the cable design knowledge JDR has acquired from over 1,000 km of installed MV cables, with zero reported cable failures.

Improvements in umbilical and power cable technology can yield significant benefits to operators in future deepwater and ultra-deep applications, offering the precise reliability expected for the subsea applications.
Thank you!